

Shaping Brains: Shaping Communities

Brain development & innovative approaches to improving children's lives



The Shaping Brains: Shaping Communities study aimed to gain an understanding of the latest research on brain plasticity during childhood and to identify interventions that can help children overcome learning difficulties, trauma or negative early life experiences.

The research was conducted by The Benevolent Society as a study tour visiting over 45 academics and practitioners in Australia, Europe, USA and Canada. The research was made possible by the inspirational thinking and generous support of the Margaret Pemberton Foundation.

This report summarises the results of the study tour and highlights implications for policy and practice.

KEY POINTS

The early years and the brain

- Neuroplasticity refers to the brain's ability to change itself in response to the environment and to learn from experience. The brain is the only organ able to do this.
- An understanding of neuroplasticity can be used to enhance children's learning potential.
- The early years are a crucial time for brain development. The foundations for most brain functions appear to be laid down early in life. Then, as the brain matures, these foundational pathways act as scaffolding on which stronger and more sophisticated pathways are built.
- There is considerable evidence that children from socioeconomically disadvantaged backgrounds and families with high levels of conflict, trauma and abuse, may experience less than optimal development of their foundational pathways and skills.
- Failure to develop foundational skills can have a cascading effect, as later learning is inhibited by the lack of basic skills.

Implications for practice and policy

- Interventions which strengthen young children's foundational skills or which directly target 'bottlenecks' to learning can result in improvements in the associated skill area. Some interventions have also shown evidence of wider benefits, such as improvements in children's academic performance or general wellbeing.
- The strongest evidence of effectiveness comes from research studies that measured changes to the brain's structure and function as a result of the intervention – as well as improvements in behaviour and academic achievement.
- Interventions were more effective when children practiced skills in everyday life as well as during training sessions, and when the intervention program was embedded into the school curricula or regular activities rather than delivered as a supplementary program.
- The Benevolent Society is now integrating these findings into its early childhood programs to help disadvantaged children develop strong foundational skills and overcome bottlenecks to learning, as part of a 2-year pilot.

NEUROPLASTICITY AND THE HUMAN BRAIN

Neuroplasticity refers to the brain's ability to change itself in response to the environment and to learn from experience. The brain is the only organ able to do this.

Experience shapes the structure of the brain because all experience, behaviour and thought involves the firing of neurons and movement of electrical impulses in the brain. This can be summed up by the following phrases:

- **Neurons that fire together wire together** – this describes the process where pathways of neurons that are used often are strengthened and become faster and more automatic; that is, the more we do something, the easier and faster we get at doing it.
- **Use it or lose it** – this describes the opposite process whereby pathways that are not used regularly break down and are 'pruned' away.¹

Early childhood brain development

Despite this lifelong ability to change, the early years of childhood are still a crucial time for brain development. The foundations for most brain functions appear to be laid down early in life. Then, as the brain matures, these foundational pathways act as scaffolding on which stronger and more sophisticated pathways are built. For example, before children can develop higher level cognitive skills such as perceptual and emotional capabilities, they need to establish foundational skills in primary sensory areas such as vision, hearing and gross motor movement.²

Acknowledgments

This research snapshot is based on a research study tour conducted by Dr Margaret Brechman-Toussaint, a Benevolent Society staff member and clinical psychologist with specialisation in the child and family area. The Benevolent Society would also like to thank the Margaret Pemberton Foundation whose generous support made this research possible.

Factors in a child's environment which optimise healthy brain development and learning include:

- *Secure attachment* to caregivers early in life; which protects against changes in the brain associated with disadvantage and early life trauma,³ and promotes focussed attention.⁴
- Contact with a *charismatic adult*; which inspires a child to engage in new experiences, develop a positive can-do mindset, build strength and hope.⁵
- *Stimulating, natural environments*; the presence of nature (trees, grass, animals) allows systems in the brain responsible for attention and executive functioning to rest and refresh.⁶
- *Excitement and novelty*; which stimulates the senses (vision, hearing and touch) and increases motivation, memory and capacity to learn.⁷
- *A positive, can-do environment*; which supports a child to have positive expectations about their intellectual capabilities and make positive attributions about mistakes, increases their engagement in the learning process.⁸
- *A motivating environment*; in which people are cooperative, willing to learn from each other, feel safe and secure, and willing to take risks.⁹

Factors that can impact negatively on healthy brain development and learning

Just as certain factors enhance aspects of brain development, other factors may lead to less than optimal development and functioning. These include:

- exposure prior to birth to toxins, drugs and alcohol and elevated levels of stress hormones

The Benevolent Society

The Benevolent Society is Australia's oldest charity. Established in 1813 we have been caring for Australians and their communities for nearly 200 years. We are a secular, non-profit, independent organisation working to bring about positive social change in response to community needs. Our purpose is to create caring and inclusive communities and a just society.

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- lack of oxygen at the time of birth, or overstimulation of a premature baby by exposure to busy environments where there is noise, bright lights and lots of people, before they have reached their full term date
- early exposure to lead, pesticides and other toxins in the environment
- poor diet, lack of exercise and a failure to develop social connections with others.¹⁰

Brain development in disadvantaged children

Brain development is also affected by the experience of **stress** early in life. This can be caused by:

- trauma or abuse, including witnessing high level conflict
- being raised in a socio-economically disadvantaged family where there is, for example, parental stress, insufficient food or other resources, an under-stimulating environment and limited quality interactions between parent and child.

There is consistent evidence that the long-term presence of these negative early life experiences can disrupt brain development, with potentially long-lasting impact.¹¹

The impact of stress on the developing brain

Stress and trauma result in changes in the production of the stress hormone cortisol, which can impact brain development. For example, if cortisol is elevated for extended periods, it can inhibit the growth of synaptic connections and kill off synapses. Cortisol can also result in over-pruning in the prefrontal cortex of the brain, meaning that important pathways that would normally be strengthened and consolidated are instead pruned away. This is often seen in children who have experienced abuse early in life.¹²

A number of research studies have found that children from disadvantaged or abusive backgrounds may not have as well developed language, attention and executive functioning skills as other children.¹³ Similarly, children who had experienced abuse or neglect were less able to regulate emotion, correctly identify emotions in others or respond differently to positive versus negative verbal or non-verbal feedback, compared to children who had not experienced abuse.¹⁴

These problems reflect a failure to establish strong foundational skills. This can result in a cascading effect once children enter school because they then do not have the necessary scaffolding on which the higher learning can be built.¹⁵

Failure to develop strong foundational skills, and to have a smooth transition to school, are risk factors for poor academic achievement in the long term, particularly among vulnerable and disadvantaged children.¹⁶

A lack of strong foundational skills and/or a poor school transition can affect self-esteem, create expectations of future failure and result in disadvantaged children lagging behind their peers.

Bottlenecks to learning

Certain skill areas can also act as ‘bottlenecks’ to learning if they are not properly developed.¹⁷ For example, a child who fails to develop attention skills to their full potential is not easily able to focus on new information that needs to be learnt, and so might have problems with literacy and maths.

Evidence suggests that some of the common bottlenecks to learning, such as limited capacity in attention and working memory, are more prevalent in children from disadvantaged backgrounds.¹⁸

A number of areas of brain functioning have been identified as likely bottlenecks to learning:

- *Emotional regulation skills*: An inability to understand and manage emotions makes it difficult to pay attention to what needs to be learnt, resulting in a failure to develop sustained attention skills. Children who cannot control

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their emotions may fail to develop positive relationships with teachers or peers, thus setting up negative expectations about their capabilities which then limit the child's capacity to learn.

- **Attention skills:** An inability to pay sustained attention, or to ignore irrelevant stimuli, means a child is not readily able to concentrate on new information that needs to be learnt. This limits the amount of information that enters the brain for further processing, meaning that higher level cognitive processes do not become engaged and thus are not well developed.
- **Executive functioning skills:** An inability to be flexible in thinking or to tolerate distraction make it difficult for the brain to problem solve, reason or engage in abstract or higher level thinking. Executive functioning skills are identified as one of the strongest predictors of school readiness and success in school.¹⁹
- **Memory:** Limited working memory, or the capacity to hold things in memory, means that tasks such as mental arithmetic or remembering another person's instructions cannot be adequately performed. In addition, for new

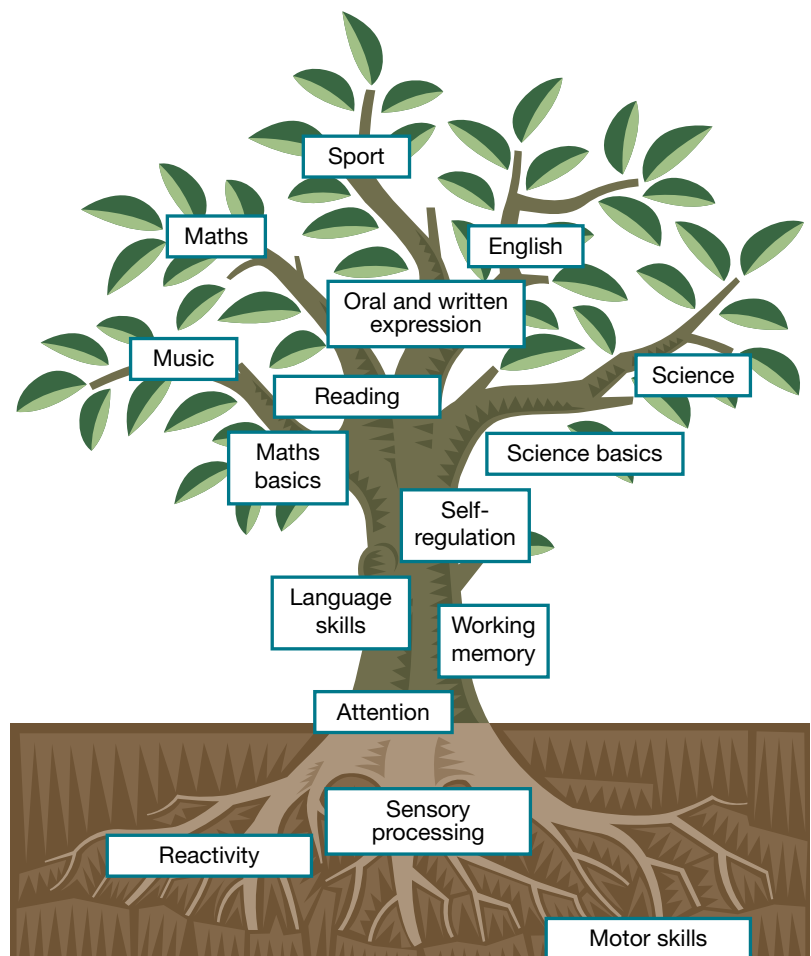
The learning tree – a metaphor for brain development

One way to think of brain development and learning is as a growing tree.

The tree is supported by a network of roots and a trunk – which represent the skills that are necessary in order to learn effectively. The limbs of the tree represent the basic skills of reading, oral and written expression, maths and science skills, and music and art.

Growing out of these limbs are the smaller branches, which represent the different domains of learning as taught in the school curriculum, subject by subject. As the child rises through the grades, the network of branches become increasingly intricate. And the trunk needs to be strong enough from year to year to support this growth in the branches.

If a child arrives at school with well-developed roots and a strong trunk then they are well able to adjust to the school environment and ready to learn – a strong trunk and root system are precursors to the strength of the branches. However, if the trunk and roots are not sufficiently developed, the child may lack the skills to learn.



Similarly, if a school curriculum only works on the branches alone, then the trunk doesn't grow at the necessary rate to support the branches - like trying to build a house without a strong foundation.

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learning to be consolidated into long-term memory, it needs to be rehearsed in working memory. In this way, limited working memory also affects long-term memory as it reduces the amount of information that is stored and can be retrieved in the future.

- *Visual and auditory processing skills:* Reading in particular, requires an ability to identify subtle differences in the sounds of language, to be able to differentiate the letters of the alphabet and to learn letter-sound correspondence. If the pathways for these skills are not well developed children may not readily master reading.
- *Theory of mind skills:* An inability to understand other people's perspectives or to take into consideration the desires and goals of others, may inhibit children from developing adequate skills for social competence and empathy. It also limits the capacity for children to engage in joint focused attention (where, for example, parent and child direct each others attention to objects of interest and share communication about what they both see) which in turn facilitates new learning.
- *Positive mindsets:* If children do not believe that they have the capacity to learn or that others will

support them in their learning, it may all seem too hard and they may not apply themselves to learning.²⁰ This will inhibit new pathways developing to their full potential.

- *Motivational and reward systems:* Similarly if children cannot see any internal or external benefit from learning, they may not be interested in trying to learn, may fail to attend to learning material,²¹ and learning pathways will not fully develop.

Children can experience multiple bottlenecks at the one time, and because skill sets overlap, a learning problem (such as reading difficulties) might be the result of several bottlenecks.²²

Promising practices

By identifying these likely bottleneck areas, interventions can be targeted to improve the development of foundational skills of disadvantaged children to enable them to reach their full learning potential.²³

The Shaping Brains: Shaping Communities study tour identified programs that are showing promising results overseas. Table 1 lists some of these programs.



Table 1: Promising interventions targeting bottlenecks and foundational skills development

Name of intervention	Bottleneck/skill targeted	Intervention type	Evidence of effectiveness
Attention and Parent Management Training	Sustained attention	Training program for parents and children. Children engage in activities that promote attention skills. Parents are taught to better manage their own emotions, understand brain development, and how to help children manage emotions and behaviour.	Randomised controlled trial showed: <ul style="list-style-type: none"> • increased attention • increased language, numeracy and social skills • increased pre-literacy skills and non-verbal IQ • decreased problem behaviour.
Tools of the Mind http://www.mscedu/extendedcampus/toolsofthemind/	Executive functioning	Preschool teacher uses 40 different play activities integrated into school curriculum over a year to promote executive functioning.	Extensive research showed: <ul style="list-style-type: none"> • children perform better than peers on memory attention and inhibition tasks. • transfer of learning to new activities and educational gains are maintained over time (but only when the program is delivered in the curriculum – not as a subsidiary program).
Cogmed © www.cogmed.com	Executive functioning	Computerised training program for attention problems linked to poor working memory. Child completes 30 minutes of training 5 days per week for 5 weeks.	Randomised controlled trial and brain imaging showed: <ul style="list-style-type: none"> • improved performance on tasks • decreased ADHD symptoms • increased blood flow, binding potential and reuptake of the neuro-transmitter dopamine in the brain.
Kids in Transition to School http://www.oslc.org/projects/popups-projects/kits-transit-school.html	Multiple bottlenecks including: <ul style="list-style-type: none"> • emotional regulation • behaviour regulation • attention • social skills • early literacy skills 	Program for 4-5 year old children in foster care. Therapeutic playgroups for child, foster carer and parent (where relevant) in the 2 months before and after school starts. Focuses on promoting early literacy, establishing routines and developing positive relationships with school.	Randomised controlled trial with follow up after 3 years, and measures of brain chemicals and activity showed: <ul style="list-style-type: none"> • increased literacy skills • improved emotional control and inhibition of distractions • improved academic achievement • evidence of changes to brain chemicals in the area for emotional and behaviour regulation and memory.
Changing Brains DVD http://changingbrains.org/	Brain development	Teaches about the different domains of development early in life, what to expect as these domains develop, and how to promote healthy development across each.	Not yet trialled in research.
Rave-O http://ase.tufts.edu/crlr/RAVE-O.html	Reading problems	Training program for 2nd and 3rd grade children with reading problems. The program focuses on phonological and decoding processes, vocabulary development and also incorporates the latest knowledge about how words are retrieved from memory and other sub-processes of reading.	Randomised controlled trial showed improved: <ul style="list-style-type: none"> • word identification • reading accuracy and rate • comprehension • vocabulary.

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Evidence for these interventions

Although evaluation methods and levels of evidence vary for each intervention listed above, all represent promising practice and are worthy of further investigation.

Despite being early days for this field of research, it is clear that the strongest evidence for neuroplastic change will come from research that includes measures of brain functioning as well as measuring change in behaviour or academic performance.

Two programs identified during the study tour, *Attention and Parent Management Training* and *Kids in Transition to School*, included these measures in their research. The results showed that it is possible to have a positive impact on areas of the brain which had previously showed signs of being negatively affected by early stress and disadvantage.

There is also some evidence that interventions are more effective when children practice skills in everyday life as well as during training sessions, and when the intervention program is embedded into the school curricula or daily activities rather than delivered as a supplementary program. This highlights the importance of practicing a new skill in different circumstances over a period of time.

Overall, the findings of the study show that interventions which directly target bottlenecks to learning do show improvements in the associated skill area. In some cases there is also evidence of wider benefits such as improvements in children's academic performance or their general wellbeing.

Phase 2 of the Shaping Brains: Shaping Communities project

Based on the findings of this research, The Benevolent Society is now starting to integrate the principles of neuroplasticity into early childhood programs in South East Queensland and South West Sydney. Six interventions, including some listed in Table 1, will be made available to disadvantaged and vulnerable children as part of a 2-year pilot project.

These interventions aim to promote development of foundational skills and overcome bottlenecks to learning, enhancing child development and strengthening positive family and community networks so that children's new learning is supported and maintained.

More information can be found on our website www.bensoc.org.au



POLICY AND PRACTICE IMPLICATIONS

This research highlights policy and practice implications for educators, workers, service providers, policy makers and government:

Teach parents about brain development and that this is influenced by how they interact with their child. Teach them about the different areas of development early in life, what to expect as these areas develop, and how to promote healthy development. Including, how to help their child to learn self-regulation skills to manage emotions and behaviours and how to self-reflect as they mature. It would also involve teaching parents how to promote joint, sustained attention, healthy lifestyles and rewarding family and community connections.

Teach children about their brain - how it controls their thoughts, feelings and behaviour and how they can look after it.

Inform educators and childcare workers about brain development and the different domains of development in early life, what to expect as these domains develop, what to look for as indicators of limited foundational skills, difficulties or bottlenecks to learning, how to promote healthy development in each domain and how to help children overcome early difficulties.

Develop practice guides and training programs to enhance educators and specialists' understanding of how the neuroscience evidence base can guide assessment and practice.

Continue intervention programs through the school years – reflecting the brain's ongoing ability to change during these years.

Develop a school curriculum that focuses on and develops each area of the brain, including foundational skills – reflecting the latest neuroplasticity findings.

Screen children to identify bottlenecks to learning at entry to school and preschool. Developing and using such screening tools would bring educational testing inline with the latest evidence from neuroscience.

Tailor interventions to address bottlenecks and promote neuroplasticity to strengthen learning. Strategies for overcoming bottlenecks can be embedded into existing programs and made available to children who are demonstrating a lack of competence in these particular areas.

Place more emphasis on interventions designed to **promote the development of foundational cognitive skills** that promote school readiness such as attention, inhibition of irrelevant information or working memory. This is particularly important for children who have experienced early life stress including children from disadvantaged backgrounds, in foster care or at risk of being removed from their homes.

Promote healthy lifestyles with an emphasis on benefits for the developing brain, and promote understanding of the impact of stress.

REFERENCES

A full list of references is available on our website.

References for promising practice interventions:

Attention and Parent Management Training: Fanning, J. L., Currin, J., Klein, S., Neville, H.J. (2009). Enhancing neurocognitive function in Head Start preschoolers: Comparing the efficacy of two attention-training programs [Abstract]. *Society for Research in Child Development*. April 2-4.

Tools of the Mind: Diamond, A., Barnett, S., W., Thomas, J., & Munro, S. (2007a). Preschool program improves cognitive control. *Science*, 318, 1387-1388.

Cogmed®: Klinberg, T., Fernell, E., Oleson, P. J., Johnson, M., Gustafsson, P., Dahlstrom, K. (2005). Computerised training of working memory in children with ADHD: A randomized, controlled trial. *Journal of American Academy of Child and Adolescent Psychiatry*, 44, 177-186.

Kids in Transition to School: Pears, K. C., Fisher, P. A., & Bronz, K. D. (2007). An intervention to promote social emotional school readiness in foster children: Preliminary outcomes from a pilot study. *School Psychology Review*, 36, 665-673.

Changing Brains DVD: University of Oregon © Neville, H. (Executive Producer), Changing Brains: Effects of Experience on Human Brain Development. University of Oregon Brain Development Lab (2009). www.changingbrains.org

Rave-O: Wolf, M., Barzilai, M., Gottwald, S., Miller, L., Spencer, K., Norton, E., Lovett, M., & Morris, R. (2009). The RAVE-O intervention: Connecting neuroscience to the classroom. *Mind, Brain, and Education*, 3, 84-93.